§37. Impurity Line Emission Measurement with Tangentially Viewing CCD Cameras

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Charge Coupled Device (CCD) cameras have widely been used for observing plasma dynamic behavior, impurity line emission profiles and plasma-wall interactions, etc.1) We have installed four CCD cameras with interference filters in a tangential port (6-T). We can choose appropriate four interference filters among six kinds of filters (OII: 442.5nm, CIII: 465.4nm, CII: 426.7nm, HeI: 587.8nm, HeII: 468.6nm and H_α: 656.6nm) for this camera system. The image data taken by the cameras are transferred to a standard S-VHS recorder and an MPEG-2 image encoder system.

1. Observation of a magnetic island structure

We took some interesting images of the impurity line emission profile. For example, the two-layer structure of the line emission (CII) was observed in the plasma start-up phase as shown in Fig. 1 (a). We have already found the presence of an m/n=1/1 magnetic island in the plasma periphery by magnetic surface measurement using a fluorescent method under high magnetic fields.2) We thought that this two-layer structure was ascribed to the magnetic island: the trapped carbon ions in the magnetic island spread along the magnetic field lines to form the emission profile along the island structure. We calculated the three dimensional magnetic island structure by using a magnetic field analysis code (HSD) including the effect of the error field which is consistent with the experimental results. Figure 1 (b) illustrates the calculated magnetic island seen from the tangential port. The calculation agrees with the observed image. We also confirmed the formation of the two-layer structure with a CCD camera installed in another tangential port (7-T). By changing the configuration of the current of Local Island Divertor (LID) coils, we investigated the dependence of the two-layer structure on the magnetic island width, which showed that the calculated images agreed with the measurements. The camera system will contribute investigation of impurity and neutral particle transport in magnetic islands. Furthermore, this system is applicable to the in-situ measurement of magnetic islands, i.e. magnetic islands can be identified without installing large scale systems for measuring magnetic surfaces such as an electron gun, a fluorescent mesh or movable rods, etc.

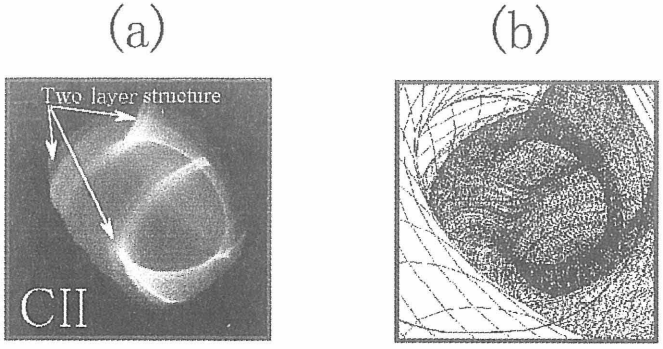

Fig.1. (a) Emission profile of carbon ions (CII) observed in the plasma start-up phase. (b) Calculated image of the magnetic island seen from the tangential port (6-T).

2. Observation of a divertor structure

A divertor structure is essential for particle control and impurity removal in long-pulse or steady state plasmas. It is important to clarify the detailed structure of the divertor plasma before designing a closed divertor configuration planed in Phase II in LHD. The position of the divertor plasma was locally measured with a fast scanning electrostatic probe, showing that the position of the divertor plasma roughly agreed with the calculation. A three dimensional divertor structure, however, has not yet been clarified. In NBI-heated plasmas, we observed a clear stripe of light, which was observed in the third experimental campaign as shown in Fig. 2 (a). We though that this stripe can be ascribed to the plasma formed along the divertor magnetic field lines. Tracing magnetic field lines from the divertor striking points on the vacuum wall by using the HSD code, we calculated the three dimensional structure of the divertor magnetic field lines. Figure 2(b) shows the calculated image seen from the tangential port (6-T), which agrees with the measurement. Consequently, we have succeeded in clarifying the divertor structure from the image taken by the CCD cameras. The detailed investigation of impurity transport and divertor physics will be performed by analyzing the images in near future.

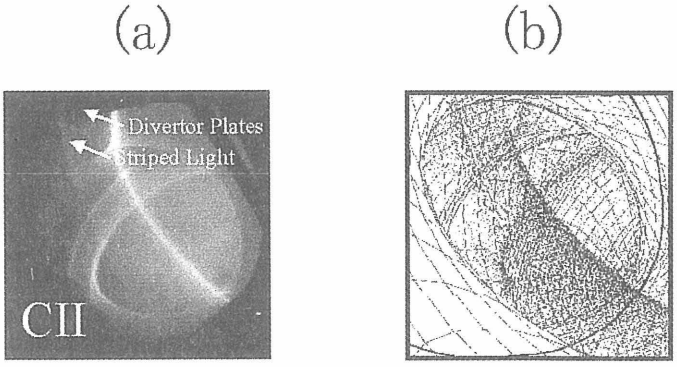

Fig.2. (a) Emission profile of carbon ions (CII) observed in an NBI-heated plasma. (b) Calculated image of the divertor magnetic field line structure seen from the tangential port (6-T).

Reference
1) Fenstermacher, M. E. et al., Rev. Sci. Instrum. **68**(1997)974.
2) M. Fujiwara et al., Proc.26th EPS Conf. on Contr. Fus. and Plasma Phys., Mastricht (1999).